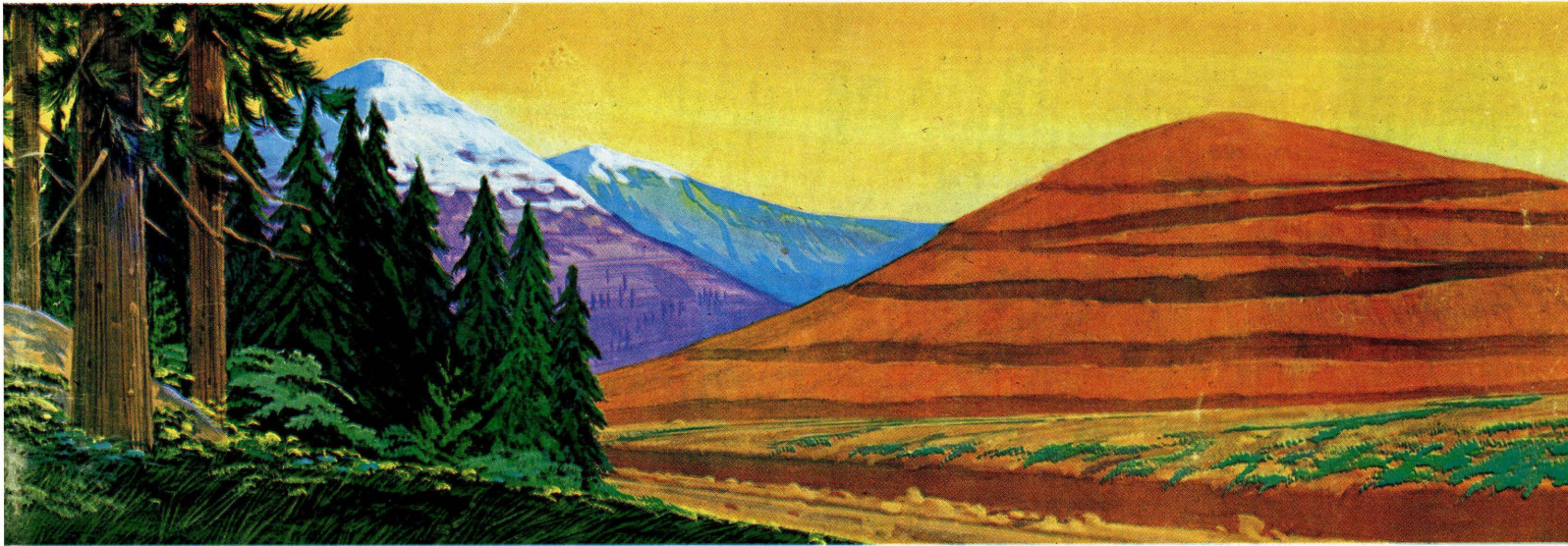


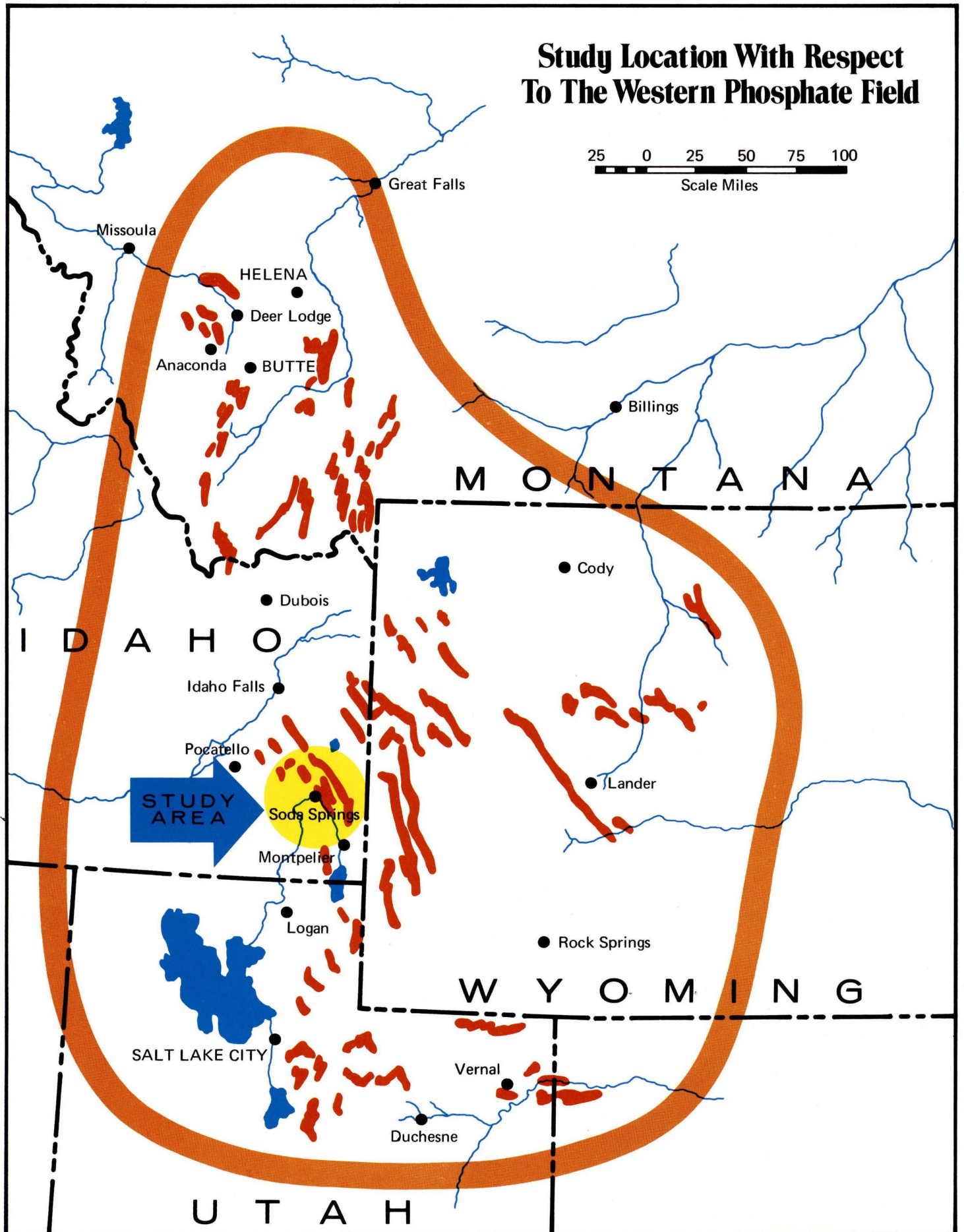
Soils
Boise NF
12.14

Surface Mine Rehabilitation



Study Location With Respect To The Western Phosphate Field

25 0 25 50 75 100
Scale Miles



Surface Mine Rehabilitation

**Report of
Cooperative Administrative
Study to Rehabilitate
Phosphate Strip-Mined Sites
January 1971**



**CARIBOU NATIONAL FOREST
MONSANTO COMPANY
J. R. SIMPLOT COMPANY
F.M.C. CORPORATION
EL PASO PRODUCTS COMPANY**

Introduction

The largest known phosphorite deposits in the United States are located in portions of Idaho, Montana, Utah, and Wyoming. Phosphorite deposits in the Intermountain area have been known for many years, but only in the last 15 or 20 years have they become a significant element in the economy of southeastern Idaho.

In early years, phosphorite deposits were mined by underground methods, but with tremendous improvement in surface earthmoving equipment, mining became more economical by surface mining methods.

Approximately 300,000 acres of the Caribou National Forest are underlain with phosphate bearing deposits. Much of the mineable deposits, based on present standards, are now under lease or prospecting permit and cover some 30,000 acres. While only a portion of the area under lease will be surface mined, its physical location with respect to other surface values is often critical.

Surface mining creates many problems when the overburden is removed. As the protective cover of vegetation is removed and raw earth exposed, the stripped area is subject to accelerated runoff and erosion. Silting from eroded areas may damage small streams and turn clear waters muddy.

Rehabilitation of these areas is a tremendous task, since the overburden is composed of newly exposed rock and raw sub-surface material. They are bare, unnatural sites that require special treatment and techniques for successful revegetation.

With the continued expansion of surface mining, the phosphate industry and the Forest Service became mutually concerned with the problem of rehabilitating mined areas and minimizing the potential damage to resources adjoining the mined areas. The primary purposes of rehabilitation are: (1) soil stabilization, (2) protect water quality, (3) return to production, and (4) restore aesthetics.

With this in mind, members of the phosphate industry and the Forest Service entered into a cooperative administrative study to determine how to best rehabilitate surface-mined areas in southeast Idaho.

The following report summarizes the results of this five-year study conducted by the U. S. Forest Service, Caribou National Forest, in cooperation with the following members of the phosphate industry:

FMC Corporation
Monsanto Company
El Paso Products Company
J. R. Simplot Company

This is the early stage of a concerted mutual effort to minimize mining impacts upon other important surface resources. The Study Plan and Interim Progress Report were distributed in 1968 and 1969. This material is available on request. From these reports some companies are presently implementing rehabilitation measures in current mining plans. Hopefully, this study report may serve as a guide for rehabilitation to current and potential mine operators in this Region. Guidelines developed as a result of this study provide a basis to expand correlated development of mineral resources.

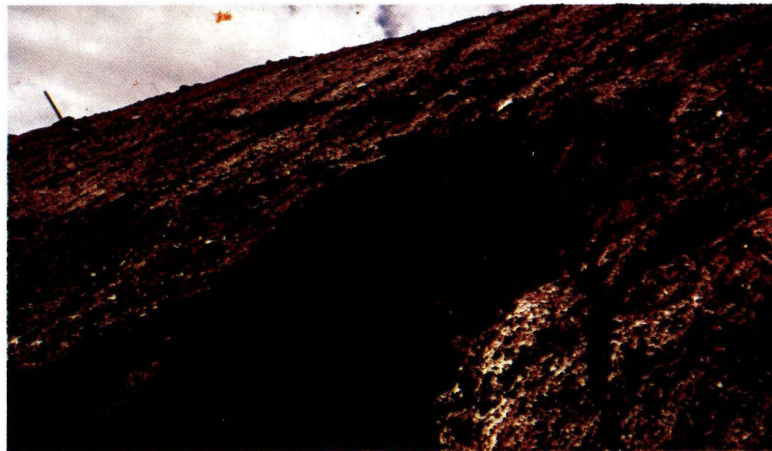
Objectives

The study was undertaken to develop practical and economical methods for achieving the following objectives:

I	Determine mechanical treatments necessary to retain moisture on site and minimize runoff.
II	Determine vegetation capable of becoming established on the harsh surface-mined areas.
III	Determine chemical and physical treatments necessary to establish vegetation.
IV	Determine micro-environmental conditions which limit plant establishment and survival.



The Problem



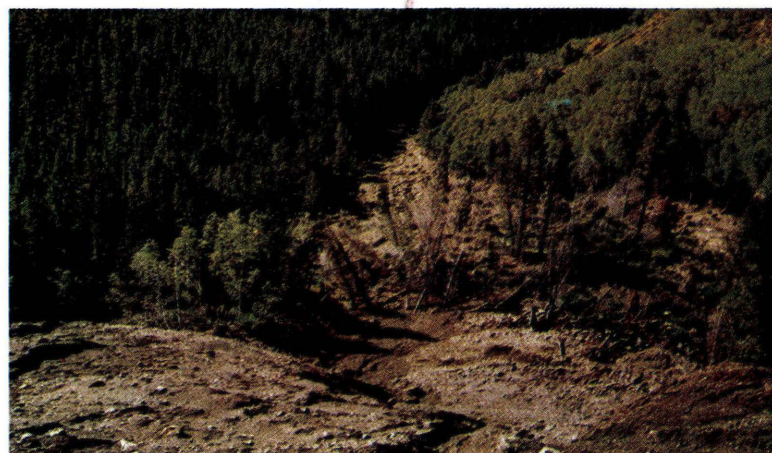
UNSTABLE
SOILS



POOR WATER
QUALITY



LOSS OF
PRODUCTION



DAMAGE TO
AESTHETICS

The Approach



MECHANICAL
STABILIZATION



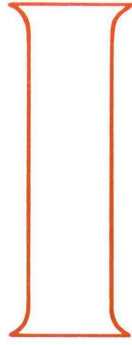
REVEGETATION



SITE
PREPARATION



MICRO-CLIMATE
CONDITIONS



Determine mechanical treatments necessary to retain moisture on site and minimize runoff.

Study Procedures

The following mechanical treatments were accomplished according to schematic diagram in Appendix 4:

1. Contour trenches.
2. 1½:1 slope angles.
3. Top of dump sloped toward headwall.



Study Results

Contour trenches must always be constructed on 0% grade. When a trench has a gradient, it acts as a ditch. Thus, water becomes concentrated causing damage and subsequent failure to trenches below.



Properly constructed contour trenches, in many cases, fill with fine material washed in from the slopes above. This material can seal the bottom of the trench and prevent free percolation of water. Once the trench capacity is reached, water spills over the edge. Trench must be designed for storage of peak flow.



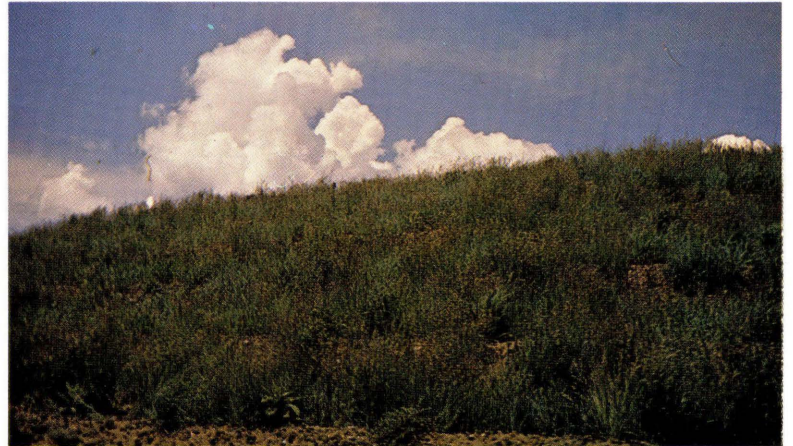
Contour intervals of 75 and 100 feet have proven unsatisfactory due to excessive water flow down long slopes. Intervals of 25 and 50 feet are desirable when trenches are necessary.



Excessive surface runoff and soil movement can take place almost immediately after material is laid down. **Plants often cannot become established due to movement of this material.**



Revegetation is directly dependent on slope stability. Much of the seed produced from established vegetation is washed off steep slopes during minor thunderstorms. If slope angles are constructed to insure stability, plant establishment of some kind can then usually follow.



Overland flow of water from the top of dump areas is extremely erosive when allowed to run down slope. Slight insloping of the top provides for ponding of water or drainage to pit areas. **Holding water in place near the top has been effective in minimizing runoff damage.** Suspended clay particles are allowed to settle out when water is stored.



Dumps constructed on $1\frac{1}{2}:1$ slopes do not provide needed slope stability. **Stabilization of steep slopes cannot be accomplished by planting alone.** Rill and gully development, and even mass movement of waste materials often prevent satisfactory results from revegetation efforts. **Preferred slope angle is at least $2\frac{1}{2}:1$ or approximately 21 degrees.**



III

Determine vegetation capable of becoming established on strip-mined areas.

Study Procedures

Since 1966, 716 plots, of varying size, have been established on three mine areas. Over 11,000 trees and shrubs were hand planted and 100 acres were seeded to numerous grasses and forbs. Minor amounts of trees and shrubs were planted using seed. Plantings were made using species as listed in Appendix V.

Planting Methods Used:	Time:	Acres Treated
A. Hand plant	Spring	Seedlings & Cuttings
B. Hand broadcast w/cyclone seeder	Spring and Fall	48 acres
C. Helicopter	Fall	46 acres
D. Hydroseeder	Fall	6 acres

Plant performance was evaluated based on adaptability, survival, growth, and vigor.



Results

Trees and Shrubs:

Growth and survival of trees and shrubs was considerably better on flat to gentle slopes. (Black Locust right). Optimum Ph for hardwoods is 5.8 to 7.3. Most spoil material has a Ph range of 6.0-8.0.



Growth and survival of trees and shrubs on 1½:1 (33°) slopes is severely impaired by instability.



Deciduous plants (those losing their leaves annually) have out-performed evergreen or coniferous species. Their relative rapid establishment and growth provides desirable cover sooner than conifers. Best survival and growth of trees found in 21 of the 40 species tried. See Appendix 1.



The use of cuttings of selected species has shown limited success to date. See Appendix I. Optimum Ph for shrubs is 6.0 to 7.0. (Sumac during first year planted).



Deciduous species do not compete favorably with grass and forbs when planted together. Shown right is a four year old Russian olive competing poorly with grass and Ranger Alfalfa.



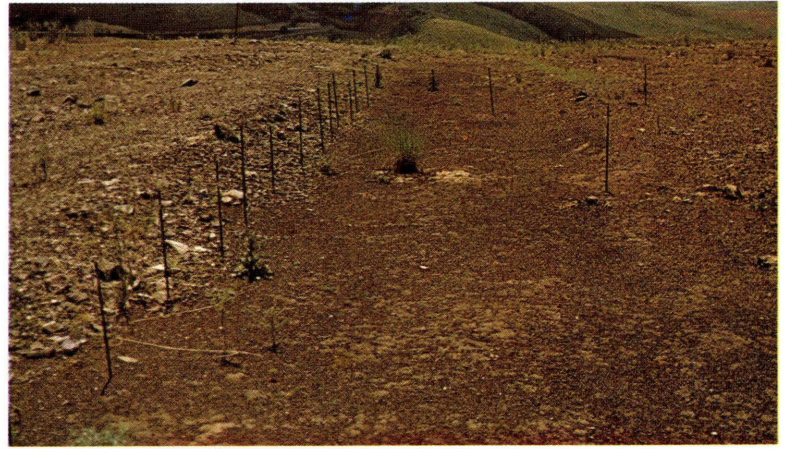
Conifers suffer from damage caused by rodents and game more than deciduous plants. Repeated terminal bud clipping is prevalent in pine plantings. Optimum Ph for Conifers is 5.2 to 5.8. If Conifers are desired, check Ph of site before planting.



Conifers show poor adaptability when planted on sites outside their natural range of occurrence. Best results have been on north and east slopes. Lodgepole pine above is on native conifer site, north slope, five years old.



Germination and survival of trees and shrubs planted by seed has been very poor. See Appendix 6 for species tried. 18 species were planted in plots. Photo is four years after planted.

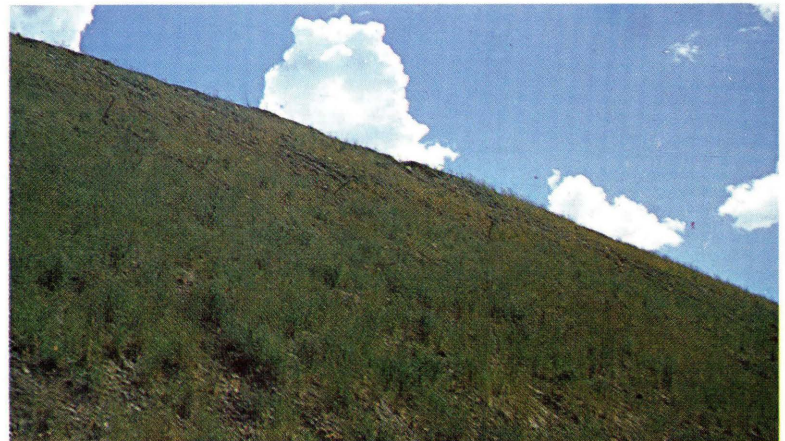


Hydroseeding has been partially successful in trials to date. Further experimentation is suggested. Both sides of road above were hydroseeded the same. With many variables involved, it is often difficult to assess plant performance with a given treatment.



Grasses and Forbs:

Best growth and performance has been found on 6 of the 12 species tried. See Appendix 2. Optimum Ph for grass is 6.0 to 7.5.



Best growth and performance of forbs was found in Ranger Alfalfa and Yellow Sweet Clover.



Crownvetch has shown good promise in the limited trials to date. It produces numerous seedlings and provides good ground cover.

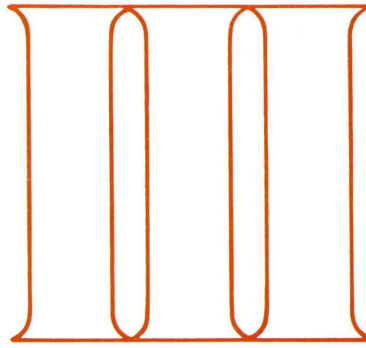


Grass and forb plantings generally do better on slopes than flatter areas. This is probably due to compaction from equipment when laying waste material down.



Stabilization of material cannot come through revegetation if stability is a problem initially.





Determine micro-environmental conditions limiting plant establishment.

Study Procedures

Plantings were established on different sites to evaluate effects of aspect, soil color and texture, and nutrient levels on plant establishment.

Micro-environment instruments were installed by the Forestry Sciences Laboratory of Logan, Utah. These instruments measure air temperature, humidity, radiation, soil moisture, soil temperature and wind. Due to difficulties involved in obtaining micro-environmental data from such widely-varying sites as occur in surface-mined areas, especially with limited instrumentation, the effects of micro-environmental variations on plant establishment cannot yet be adequately evaluated. Anticipated data does not appear to justify continued effort in National Forest administration.



Results

Aspect often determines what will or will not grow. **Conifer trees do poorly outside their range of natural occurrence.** Drought resistant species do best on south exposures. Trees responded poorly on south and west exposures. Planted conifers do best on north and east exposures. Example of natural conifers site is shown in right center of photo.



Dark color material can inhibit plant establishment and growth. Extremes in soil temperature and low soil moisture are typical of south slopes. Dark material temperatures can go as high as 155 degrees and may even reach 175 degrees. Dark material should especially be avoided on south and west slopes.



Course and fine materials mixed together were most conducive to revegetation. Area right has been ripped to a depth of two feet prior to planting.



Fine-textured material is often severely compacted preventing plant establishment and future development of plant roots. Photo shows limits in plant growth caused by compaction. Water or plant roots cannot penetrate much below 2-3" on this site.



IV

Determine chemical and physical treatments necessary for plant establishment and growth.

Study Results

Hand application of fertilizer and seed by cyclone seeder has been the most practical method on mine areas. Early spring and late fall plantings have been effective.

Nutrient levels on unfertilized areas can inhibit establishment of trees and especially grass.

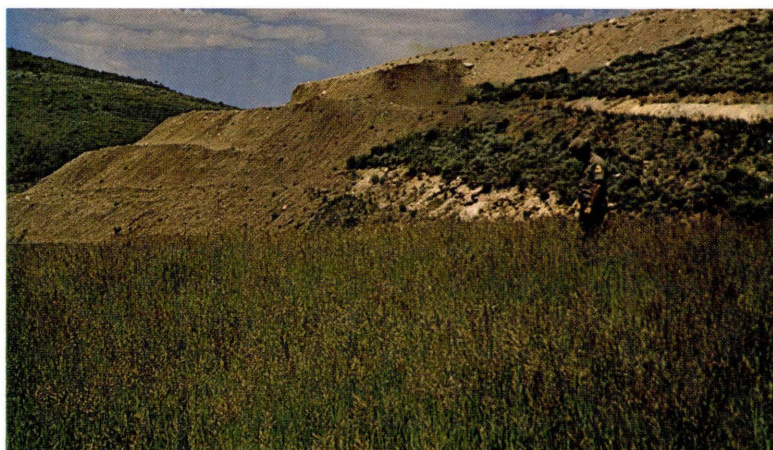
Fertilization of trees to enhance establishment has been effective. Boxelder right is shown six weeks after planting.

The following treatments were accomplished on various plots on the mines:

1. **N20 P10 K10** fertilizer applied at 200 lbs./acre.
2. **Water** for initial plant establishment.
3. **Rake** to cover seed.
4. **Scarify** for seedbed preparation.
5. **Mulch** for seed protection and cover.
6. **Nurse crop** to establish temporary crop until primary crop became established.
7. **Endrin seed treatment** for seed protection from rodents.



Grass establishment and growth on waste material has been enhanced by application of 20-10-10 fertilizer at the rate of 200 pounds per acre. Stand of brome above is two years old.



Watering during critical periods has aided establishment and survival. Watering was important during extended dry periods within the first growing season. Cotoneaster shown right is three years old — watered twice in spring.



Revegetation success is directly related to nature of material in early state of seedling development. Many adverse conditions can be overcome by 8-10" of topsoil. Stockpile and redistribute topsoil after mining. If topsoil is unavailable, use mudstones.



Ripping and scarifying was beneficial in most trials. Planting was easier and compaction was broken. This treatment lowers mortality on new plants and prepares excellent seedbed after area is ripped. Seed should be broadcast and then the area worked with a cultivator or other means to cover the seed.



Conclusions

A. Mechanical Treatments Necessary to Retain Moisture on Site and Minimize Runoff.

1. Specific dump design should be predetermined and constructed as mining progresses. Later treatment is often ineffective, very costly, and sometimes impossible. Mining plans should place materials most conducive to revegetation on the surface.
2. Tops of dumps and ore piles should be insloped to prevent down slope runoff. Utilization of pit areas and ponding of water on top of dump has been effective in preventing concentrations of water on slopes.
3. Slope stability cannot be accomplished through revegetation alone. Slopes must be essentially stable before revegetation can occur.
4. Waste slope angles of 1½:1 should be avoided wherever possible. Preferred slope angles are 2:1 - 2½:1.
5. Contour trenches are recommended when slope angle cannot be flattened to at least 2½:1.
6. When contour trenches are used, they should be constructed at 25 foot or 50 foot rise intervals with check dams at 100 foot intervals. Trenches and cross dikes must be designed for storage of peak flow. See typical mine profile drawing in Appendix IV.
7. Contour trenches **must** be constructed on 0% grade or provisions made to handle collected water if it is channeled.

B. Vegetation Capable of Becoming Established on Mine Spoil.

1. Deciduous species have performed better than conifers. Suggested species listed in Appendix 1.
2. Except for selected natural sites, conifers are not recommended for initial cover or slope stabilization.
3. Growth and survival of trees and shrubs on 1½:1 (33°) slopes is severely impaired by instability of such a slope.
4. Identify Ph before selecting conifers for a given site. Optimum Ph range for conifers is 5.2 to 5.8. Most waste material ranges from 6.0 to 8.0. Above Ph 6.5, changes in the availability of elements may be the critical factor in limiting growth of conifers.
5. Conifers, if used, should be planted alone, since they compete poorly with faster growing plants. Conifers suffer heavily from damage by wildlife, principally rodents and deer.
6. Planting trees and shrubs by seed is not recommended.
7. If trees or shrubs are desired, grasses and/or forbs should not be planted in common due to competition.
8. Cuttings of listed species have been partially successful and can be used when available (See Appendix I).

9. Of all species tried, performance of the best six grass species is listed in Appendix 2. Optimum Ph range for desirable growth response in grasses is 6.0 to 7.5. Seeding rate should be 12 lb.-16 lb. per acre.
10. Of all forb species tried, the best three performers are listed in Appendix 2.
11. Grasses seemingly do better on slopes than flatter areas. This is probably a result of compaction. Site preparation can effectively overcome this problem.
12. Growth and survival of trees and shrubs was best on flat to gentle slopes.
13. Hydroseeding trials to date were inconclusive. More experimentation is needed to determine its feasibility.

C. Micro-Environment Conditions Limiting Plant Establishment.

1. Determine natural plant occurrence and aspect before planting conifers. North and east aspects are most conducive to growing conifers.
2. Grass and forb seed plantings are most successful on finer textured soils where the seed bed can be mechanically prepared.
3. Fine textured waste material which has been compacted must be ripped to a depth of 16 to 30 inches before or during planting.
4. When laying down spoil dumps, mix fine and coarse materials when possible. These mixed

materials are not as compacted and are more readily revegetated.

5. Cover dark colored spoil with light gray to brown material as waste dumps are constructed. Dark material inhibits plant establishment and growth so it should never be left exposed on the surface.

D. Chemical and Physical Treatments.

1. When possible, determine the nutrient level of the area to be planted. A proper fertilizer mixture can then be determined.
2. Fertilization usually enhances establishment of vegetation.
3. Use of 20-10-10 fertilizer is recommended, at a rate of 200 lb. per acre, when it is impossible to determine the nutrient level on planting areas.
4. Watering is recommended for initial plant establishment during extended dry periods especially the first growing season.
5. At least 8-10" of topsoil or soil-like material is recommended for planned revegetation areas.
6. Rip or scarify planned planting areas just prior to planting especially the flatter compacted areas. Site preparation should **always** be done on the contour whenever possible.
7. Mulching and use of nurse crops had no discernable effect on treated plots. It is recommended that additional trials be made to show effects of mulch on a prepared seed bed.

Appendix



SUGGESTED SPECIES PLANTING LIST (In order of performance)

Trees and Shrubs

GENERIC NAME	COMMON NAME
Eleagnus augustifolia	Russian Olive
Populus sargenti – robusta	Cottonwood
Robina pseudoacacia	Black Locust
Eleagnus umbellata	Autumn Olive
Ulmus americana	American Elm
Cotoneaster acutifolia	Cotoneaster
Acer negundo	Boxelder
Caragana aborescens	Peashrub
Gleditsia triocanthos inermis	Honey Locust
Prunus besseyi	Sand Cherry
Prunus melanocarpa	Chokecherry
Prunus serotina	Wild Black Cherry
Syringa villosa	Late Lilac
Syringa vulgaris	Common Lilac
Lonicera tatarica	Honeysuckle
Ulmus pumila	Siberian Elm
Celtis occidentalis	Hackberry
Cornus stolonifera	Redosier Dogwood
Rosa multiflora	Rose
Shepherdia argentea	Buffalo Berry
Morus alba	Russian Mulberry

Plant Spacing and Stems/Acre:

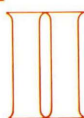
Trees 8' x 10' – 500/acre

9' x 9' – 600/acre

Shrubs 5' x 5' – 1200/acre

6' x 6' – 1800/acre

Appendix



SUGGESTED SPECIES PLANTING LIST

Grasses

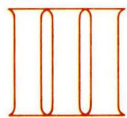
GENERIC NAME	COMMON NAME
Agropyron intermedium	Intermediate Wheat
Bromus inermis	Smooth Brome
Festuca ovina	Hard Fescue
Agropyron trichophorum	Pubescent Wheat
Agropyron cristatum	Crested Wheat
Agropyron smithii	Western Wheat

Forbs

Medicago sativa	Ranger Alfalfa
Melilotus officianalis	Yellow Sweet Clover
Coronilla varia	Crown Vetch

Planting Rate: 12 to 16 pounds/acre

Appendix



CARE OF PLANTING STOCK

It is extremely important to give the tree and shrub seedlings proper care from time of lifting to date of planting. Care must be taken to keep the roots from drying. If the plants cannot be planted soon after they are received from the nursery, they should be stored properly. Snow is an ideal storage place. Some points to remember when storing in snow are:

- (1) Location should be close so it can be checked frequently.
- (2) Place in shaded area when possible.
- (3) Do not pack snow tightly around seedlings, allow proper ventilation.
- (4) Cover cache area with tarp, burlap canvas, or sawdust; do not use any dark material that will absorb heat.

If there is no snow available, seedlings can be heeled-in. Proper way for heeling-in:

- (1) Dig a V-shaped trench deep enough to hold the roots.
- (2) Remove trees from bundles.
- (3) Place upright along one edge of trench.
- (4) Cover roots with soil.
- (5) Water immediately and keep moist, especially if the weather is hot and dry or if the trench is not shaded.

Usually a week's notice to nurseries is long enough to obtain needed stock. Good planning will eliminate much of the storage time.

Appendix

IV

TYPICAL MINE PROFILE

NOTES

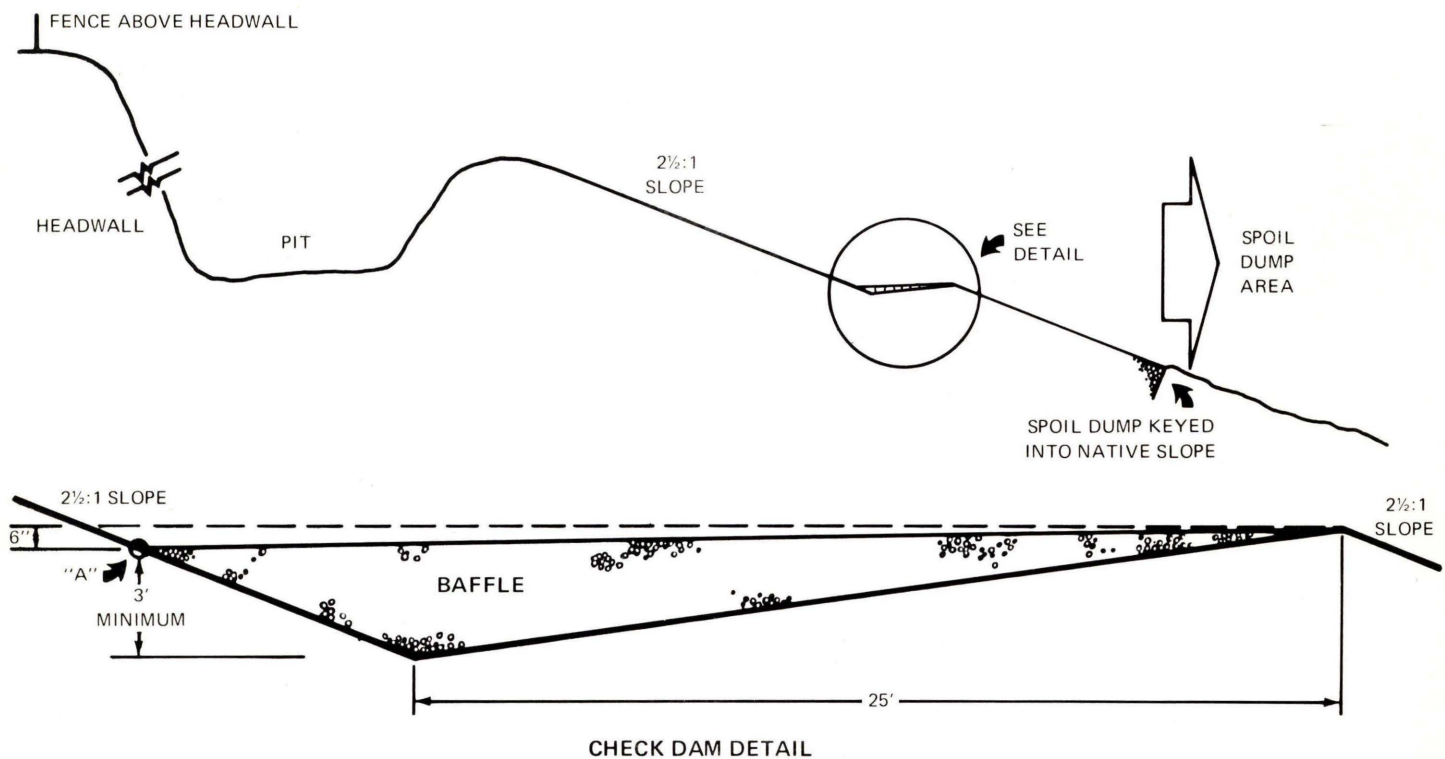
Contour Intervals: 25' or 50'

Bench Width: 25'

Place Check Dams at 50'-75'-100' Intervals

Tip Bench Back So That Inside Of Bench Is
3' Below Outside Of Bench Edge.

"A" Is 6" Below Outside Of Bench Edge.



Appendix

V

SPECIES PLANTED IN THE STUDY

Tree and Shrub Seedlings and Cuttings

GENERIC NAME	COMMON NAME
<i>Acer negundo</i>	Boxelder
<i>Ailanthus glandulosa</i>	Tree of Heaven
<i>Artemisia arbuscula nova</i>	Black Sage
<i>Caragana arborescens</i>	Peashrub
<i>Ceanothus prostratus</i>	Squaw Carpet
<i>Celtis occidentalis</i>	Hackberry
<i>Cornus stolonifera</i>	Redosier Dogwood
<i>Cotoneaster acutifolia</i>	Cotoneaster
<i>Eleagnus umbellata</i>	Autumn Olive
<i>Eleagnus angustifolia</i>	Russian Olive
<i>Fraxinus lanceolata</i>	Green Ash
<i>Fullugia paradoxa</i>	Apache plume
<i>Gleditsia triocanthos inermis</i>	Honey Locust
<i>Juniperus scopulorum</i>	Juniper
<i>Lonicera tatarica</i>	Honeysuckle
<i>Lycium halimifolium</i>	Matrimony Vine
<i>Maclura pomifera</i>	Osage-orange
<i>Morus alba</i>	Russian Mulberry
<i>Picea engelmanni</i>	Engelmann Spruce
<i>Pinus contorta</i>	Lodgepole Pine
<i>Pinus ponderosa</i>	Ponderosa Pine
<i>Populus sargentii-robusta</i>	Cottonwood
<i>Prunus besseyi</i>	Sand Cherry
<i>Prunus melanocarpa</i>	Chokecherry
<i>Prunus serotina</i>	Wild Black Cherry
<i>Pseudotsuga menziesii</i>	Douglas-fir
<i>Purshia tridentata</i>	Bitterbrush
<i>Rhus cismontana</i>	Mountain Sumac
<i>Rhus trilobata</i>	Skunkbrush
<i>Robina pseudoacacia</i>	Black Locust
<i>Rosa multiflora</i>	Rose
<i>Salix nigra</i>	Black Willow
<i>Salix purpurea lambertiana</i>	Purple Willow
<i>Salix vatellina</i>	Golden Willow
<i>Shepherdia argentea</i>	Buffalo Berry
<i>Syringa villosa</i>	Late Lilac
<i>Syringa vulgaris</i>	Common Lilac
<i>Ulmus americana</i>	American Elm
<i>Ulmus pumila</i>	Siberian Elm

Appendix

VII

SPECIES PLANTED IN THE STUDY

Appendix

VIII

SPECIES PLANTED IN THE STUDY

Tree and Shrub Seed Plantings

GENERIC NAME	COMMON NAME
<i>Amelanchier utahensis</i>	Service Berry
<i>Artemisia arbuscula nova</i>	Black Sagebrush
<i>Artemisia tridentata</i>	Big Sagebrush
<i>Atriplex canescens</i>	Four-wing Saltbush
<i>Caragana arborescens</i>	Siberian Peashrub
<i>Ceanothus velutinus</i>	Snowbush
<i>Cercocarpus ledifolius</i>	Mountain Mahogany
<i>Chrysothamnus nauseosus</i>	Rubber Rabbitbrush
<i>Cowania stansburiana</i>	Cliffrose
<i>Eleagnus angustifolia</i>	Russian Olive
<i>Fraxinus lanceolata</i>	Green Ash
<i>Juniperus scopulorum</i>	Rocky Mountain Juniper
<i>Purshia tridentata</i>	Bitterbrush
<i>Rhus cismontana</i>	Mountain Sumac
<i>Rhus trilobata</i>	Skunkbush
<i>Rosa woodsii</i>	Wild Rose
<i>Sambucus coerulea</i>	Elderberry
<i>Ulmus pumila</i>	Siberian Elm

Grass and Forb Seed Plantings

GENERIC NAME	COMMON NAME
<i>Agropyron cristatum</i>	Crested Wheat
<i>Agropyron intermedium</i>	Intermediate Wheat
<i>Agropyron smithii</i>	Western Wheat
<i>Agropyron spicatum</i>	Bluebunch Wheat
<i>Agropyron trichopherum</i>	Pubescent Wheat
<i>Bromus inermis</i>	Smooth Brome
<i>Elymus junceus</i>	Russian Wild Rye
<i>Festuca ovina</i>	Hard Fescue
<i>Festuca rubra</i>	Red Rescue
<i>Festuca spp.</i>	Alta Fescue
<i>Oryzopsis hymenoides</i>	Indian Rice
<i>Poa bulbosa</i>	Bulbous Blue
<i>Secale cereale</i>	Annual Rye
<i>Agastache urticifolia</i>	Horsement
<i>Ligusticum spp.</i>	Ligusticum
<i>Lupinus spp.</i>	Lupine
<i>Medicago sativa</i>	Ranger Alfalfa
<i>Melilotus officinalis</i>	Yellow Sweet Clover
<i>Vicia spp.</i>	Sweetvetch

Forb Cuttings

<i>Coronilla varia</i>	Crown Vetch
<i>Astragalus spp.</i>	Milk Vetch

